NOTES ON RIPPLE MARKS

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In a paper on ripple marks, recently published in the *Journal of Geology*, by Dr. E. M. Kindle, the opinion is expressed that the size of ripple marks may bear some relation to the depth of the water in which they were formed. Entertaining the same idea, I have on various occasions taken notes on the size of ripple marks. That most ripple marks vary in size with depth of the water seems to me hardly to admit of a doubt. Ripple marks from 3 to 4 inches in width appear to be most common. They are often to be seen in thoroughly sorted beach sands of all ages, from the Cambrian up to the Pleistocene.

In the Lower Comanchean, in Pecos County, in Texas, I have found some ripple marks of very small size, the smallest I have seen, with one exception. These were noted at several points in some thin-bedded layers of sandstone of fine texture. These sandy layers are interbedded with clays and limestones. A piece of this ripple-bedded rock is shown in Fig. 1, in natural size. Twelve ripples measure together 3 inches across, making an average of one-fourth inch for each ripple, from crest to crest. The depth of the troughs measures about one twenty-fifth of an inch. These ripple marks are symmetrical. A rough mechanical analysis of the sand in this rock is as follows:

Diameter of Grains in Millimeters	Percentages by Weight
1/8 –1/16	80
1/16–1/32	20

Two years ago I found ripple marks of the same size, or possibly slightly smaller, forming in some fine sandy silt in the Rio Grande, in Webb County. The silt had been washed up on some large blocks of sandstone, which were strewn in the channel of the river. It lay in shallow depressions on these rocks, and the water covered

the ripple marks from a half to one inch deep. The wind stirred the surface of the water gently into small waves, and the ripple marks in the sand were seen to be building, under the influence of these waves.

Fig. 2 shows some ripple marks in a fine silty sand of the marine Jurassic, near Minnekahta, South Dakota. They measure $1\frac{1}{3}$ inches from crest to crest and have an average depth of fifteen-hundredths

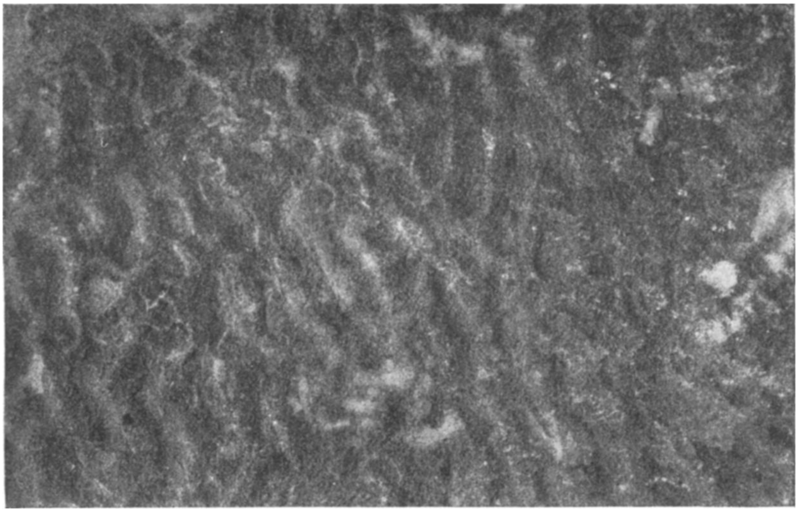

FIG. 1.—Ripple marks in Comanchean sandstone, from Pecos County, Texas. Natural size.

of an inch. These ripple marks are unsymmetrical, their longer slopes bearing the average ratio of 152 to 100, to the shorter slopes. A mechanical analysis of the sand in this rock was found to be, roughly, as follows:

Diameter of Grains in Millimeters	Percentages by Weight
1/2 –1/4	Trace
1/4 –1/8	55
1/8 –1/16	30
1/16–1/32	15

Some large-sized ripple marks occur in the Ordovician dolomites at Utica, in Illinois. In the old entries where cement rock long ago

was mined for the Utica Cement Works, some ripples have been disclosed that measure from 4 to 5 feet across from crest to crest. This is in a somewhat thin-bedded dolomite, which contains some sand. Evidently this limestone was not a shallow-water deposit. The ripple-bedded layers lie some 100 feet below the base of the St. Peter sandstone.

The widest ripple marks that have come under my observation are in a crinoidal limestone in the lower part of the Burlington,

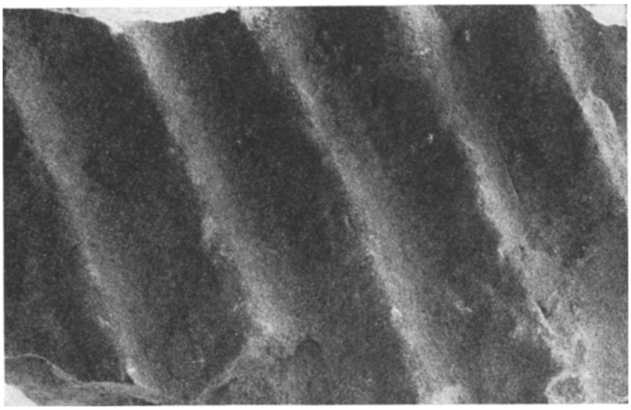

FIG. 2.—Ripple marks on Jurassic sandstone, near Minnekahta, South Dakota. One-half natural size.

in the southeast part of Louisa County, in Iowa. These ripples measure nearly 6 feet from crest to crest, and are at least 6 inches deep. The presence of crinoidal remains in this rock, which contains some shaly material, indicates, if not proves, deep-water conditions. How deep?

Higher up in the geological column I have seen some quite large ripple marks in the Comanchean, in Texas, in a horizon near the Kiamitia clay. About 17 miles west-southwest from Kerrville such ripple marks occur in the bed of Guadalupe River (see Fig. 3). They measure about 14 inches across and are about 1½ inches deep. They are slightly unsymmetrical. The rock in this case is a mixture of calcareous and shaly material, which contains variable quantities of fine sand, so that some layers might more properly be called

sandstone. The same horizon is exposed in the bottom of Bosque River, at Clifton, 155 miles northeast from the locality just mentioned, and again some 6 miles north of Clifton in the same beds in the same stream. Some layers of limestone here show ripple marks that measure 4 feet across, near Clifton (see Fig. 4), and from 2 to 3 feet across at the northernmost locality (Fig. 5). The lime-

FIG. 3.—Ripple marks in thin-bedded sandy limestone in the bottom of Guadalupe River, about 17 miles southwest of Kerrville, Texas.

stone layers here are compact and quite pure in composition, but are interbedded with marly shales.

Perhaps it may be permitted to submit some general remarks anent the phenomena of ripple marks. They shall be brief. Ripple marks must be due to rhythmic variations in currents in the medium of sedimentation. They are in this respect kin to wavelike etchings, known to be caused by rhythmic movements of corrading currents. Perfectly symmetric ripple marks are probably the result of to-and-fro movements of equal extent in both directions, when these movements are such that the velocity of the motion happens to be

sufficiently strong to move material of the coarseness present where the rhythmic motion prevails.

On the bottom of any billowy water, sufficiently shallow for the size of the waves, there must be a to-and-fro motion for each passing wave. For waves of the same size, the deeper the water the more slow and the more limited will this motion be. Hence the less will

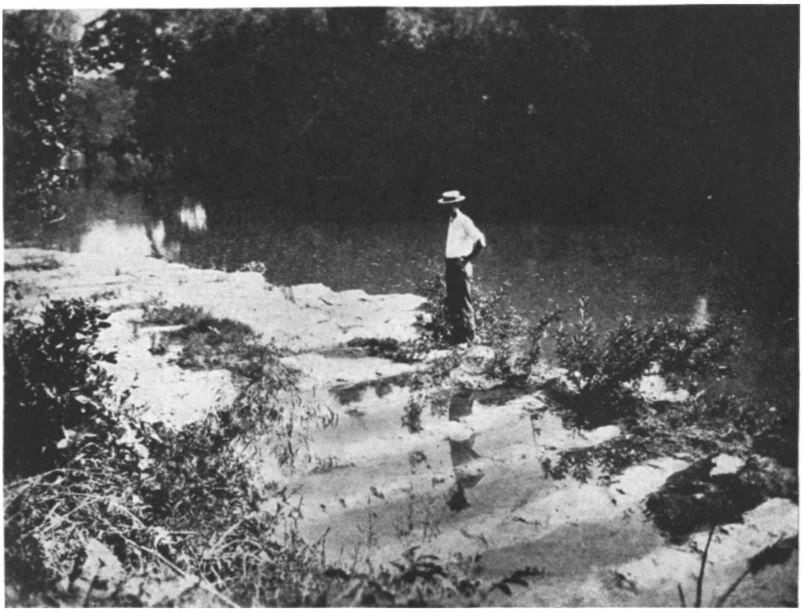

FIG. 4.—Ripple marks in Comanchean limestone in the right bank of Bosque River, near Clifton, Texas.

be the diameter of the particles it will be able to stir. There must be a certain depth where the motion will be just speedy enough to stir particles of silt. Where the bottom lies at this depth, and where it is covered with silt, ripple marks will form. Should not their width be determined by the extent of the to-and-fro movement in each direction? This decreases downward according to a known law.

It is evident that the velocity of each to-and-fro movement on the bottom of an agitated body of water begins with zero, rises to a

momentary maximum, and falls again to zero. For particles of different sizes, there must be different times of duration of speeds attaining and exceeding the respective limits effective for their transportation. This time, and hence the latitude of this effective translatory motion, will increase with the fineness of the stirred sediment. With waves of one and the same size, and with the

FIG. 5.—Ripple marks in Comanchean limestone in the bed of Bosque River, about 6 miles north of Clifton, Texas.

same depth of water, the width of ripple marks should be greater in fine sediments than in coarse. The currents producing them will carry fine elements farther than coarse. With waves of the same size ripple-mark building in sand should then also take place in somewhat more shallow water than ripple-mark building in silt.

Some ripple marks must be produced by a wavelike or rhythmic motion which results from a reaction by the transported material on translatory bottom currents in water and in the air. No surface

billows in the atmosphere can have anything to do with ripple marks in dune sands. Do dune-sand ripple marks vary in size with wind velocity and coarseness of the sand? They do not vary very much. May ripple marks be formed by a like reaction with bottom currents in deep water? If so, their variation in size may also be small. Such ripple marks, like those in sand dunes, should always be unsymmetrical. Their sizes are probably independent of depth of the water.